

REMARKS/ARGUMENTS

Claims 1, 4 and 14 have been amended to delete the term "about" in the description of the length of the long glass fiber component.

Claim 8 has been amended to change its dependency from claim 3 to claim 2.

Claim 13 has been amended to change "calculated resistance" to "calculated creep resistance". Support for this amendment is provided in the specification at page 7, lines 16 to 20.

Support for new claim 19 is provided in the specification at page 6, lines 6 to 9 wherein it is noted the that composite may contain "one or more additional optional components such as for example, colorants, lubricants, processing aids, stabilizers, and the like."

Support for new claim 20 includes the following: at page, 1, lines 7 to 8 of the specification it is noted that invention "relates to fuel cell endplates fabricated from a thermoplastic resin composite"; at page 4, lines 14 to 18, the thermoplastic resin composite is described as a "long fiber reinforced composite" produced by "pultrusion or other techniques that imbed a relatively high loading... of long strand fibers in the polymer matrix"; at page 5, lines 4 to 7, composites having fiber contents of "from about 40 to about 60 weight percent" are disclosed; at page 4, line 28 to page 5 line 2, the use of long strand glass fiber composites is disclosed, it being noted that the "use of composites wherein the long strand glass fiber ... preferably from about 5mm to about 20mm, in length is desired"; and at page 5, line 28, wherein polyphenylene sulfide is included in the list of materials exemplified as useful thermoplastic resins.

In view of the comments that follow, reconsideration and allowance of the subject claims, as amended, is respectfully requested.

This Amendment follows a telephone interview between Examiner Raymond Alejandro and the undersigned held on June 24, 2003, the substance of which is summarized in the Examiner's Interview Summary Sheet. The undersigned supplements that Summary with the following additional comments. The Examiner's comment that "It was also pointed out that the claimed endplate is non-conductive while the prior art plate requires to be conductive", references a discussion regarding Wilson et al. ("Wilson"). The undersigned raised the possibility of amending the claims to distinguish the glass fiber-containing composites of the subject application from the conductive composites disclosed by Wilson, with no agreement being reached regarding such an amendment or the form of such claims. There was also a discussion of long and short strand fiber, with the Examiner repeating his position that the composites of Wilson and those of the subject composites were substantially similar as regards fiber length, and the undersigned taking exception thereto.

Claims 1 to 4 and 6 to 18 stand rejected under 35 U.S.C. 103(a) as unpatentable over Wilson in view of Guthrie and further in view of Carlstrom.

The only independent claims of the subject application are amended claims 1 and 14, and new claim 20. Amended claim 1 describes a molded fuel cell endplate fabricated from a long fiber reinforced composite comprising a selected thermoplastic and least about 30 weight percent of long glass fiber at least 5 mm in length. Amended Claim 14 describes an injection molded fuel cell endplate fabricated from a long fiber reinforced thermoplastic resin composite comprising polyphenylene sulfide and about 45 to 55 weight percent of long strand glass fiber 10mm to 15 mm in length. New claim 20 describes an injection molded fuel cell endplate fabricated from a thermoplastic resin composite consisting essentially of polyphenylene sulfide and glass fiber, wherein the composite is a pultruded long glass fiber reinforced composite that contains from about 40 to about 60 weight percent of long strand glass fiber at least 5mm in length.

It is respectfully submitted that long-glass fiber reinforced composites are recognized in the plastics art as being different from composites produced by the compounding of conventional short glass fiber. A general description of glass-reinforced thermoplastic resins may be found in the Concise Encyclopedia of Composite Materials, © 1989 Pergamon Press, at pages 113 to 116 (copy attached). More particularly, in the second column at page 113, there is the following discussion of fiber length:

Most compounds are produced by extrusion blending: a dry mixture of polymer granules (typically about 3 mm in diameter and length) and chopped glass strand of similar length is charged into the hopper of a single- or double-screw extruder. The charge is passed through the machine and extruded through a "spaghetti" die and chopped into granules of similar dimensions to the original charge. During the extrusion process the charge is melted and subjected to considerable shear and mixing. This produces a homogenous compound but causes the glass strand to break up into individual filaments, typically less than 500µm in length. A variation of the process is to feed continuous-fiber rovings directly into the molten polymer in a vented-barrel extruder. This causes less breakage but average fiber length seldom exceeds 1 mm. The injection-molding machine also incorporates a screw-plasticizing section which causes further fiber breakage. The significance of this is discussed below.

In the alternative compounding process a continuous-fiber roving is fed, either into a cross-head die on an extruder, or drawn through a tapered heated die fed with solid (powder) or liquid polymer. The produce is a continuous length of fiber roving completely impregnated with the polymer. This may then be cut into lengths suitable for charging into the injection molding machine, typically 5-10 mm. The distinction between the two processes is that in extrusion compounding the fibers are typically much less than 1 mm long whereas in the drawn product they are as long as the chopped pellet: any length may be selected, limited only by the feed characteristics of the molding machine to be used. The characteristics of the two types of pellet are shown in Fig. 1. These "long-fiber" compounds will suffer some fiber breakup during injection molding, but this is controllable and the final fiber aspect ratio in the molding is much greater than in the extrusion-compounded material.

Wilson discloses a bipolar separate plate made from an electrically conductive composite. The composite contains a conductive powder, preferably graphite, of a range of particle sizes predominantly between 80 and 325 mesh and a thermosetting vinyl ester resin. The conductive powder is embedded in the composite in an amount "sufficient to impart a desired level of electrical conductivity to the plate", with between

20 and 95% by weight of graphite being identified as a suitable loading of conductive powder.¹ At column 6, lines 49 to 68 Wilson notes:

While the prior art uses all ranges of graphite particle sizes, we have observed that, within a certain size range, larger particles result in higher sample conductivities. However, if the particles are much greater than 150 microns in diameter they do not wet or mix well.

To improve the mechanical properties of the composite, Wilson teaches the addition of fiber as an optional additional component. However, the patent is clear that the fiber reinforcement to be used is a relatively short material, i.e., a "microfiber" less than 1 mm in length, as opposed to a long fiber reinforcement:

Conventional composites are typically fiber reinforced to provide additional strength and/or flexibility. Traditional fiber reinforcements for structural composites include graphite, glass, Kevlar, and metal. The fibers are typically used as is but may have surface treatments designed to improve fiber-resin adhesion. "Sized" glass fibers, for example, possess functional groups at the surface that can improve adhesion or provide chemical bonds to the resin. In

¹ At column 4, lines 37 to 60, the patent states:

While the preferred embodiments utilize graphite as the conductive powder component of the material, it can be appreciated that conductive particles or powders other than graphite (e.g. metals, boron carbide, titanium nitride) may also be suitable for these composites. However, graphite has the advantages of low cost, low weight, ready availability, and chemical stability for this application.

A percolated (connected) network of conductive particles must be formed to produce an electrically conductive composite. Graphite typically percolates around 20 volume percent in a binary system, but carbon black can percolate at concentrations of less than one volume percent. Thus it may be beneficial to add small amounts (up to about 5 weight percent) of carbon black to effectively increase the number of electrical contacts between the conducting particles ...

An upper limit on the amount of graphite particles is determined by the need to provide enough resin to maintain plate integrity. This upper limit is about 95% graphite by weight. Thus, depending on the particular fuel cell design, the graphite particle loading should be between 20-95% by weight.

general, these high-strength traditional fibers impart vastly improved mechanical properties in structural composites where long fibers or fabric rovings are used and the volume fractions of resin are typically quite high (e.g. 60% or more). **In the case of electrically conductive composites for electrochemical applications, any fiber reinforcements that are used need to be relatively short to attain good fill, avoid hand lay-up, and provide a relatively homogenous structure. As a result, short “microfibers”(< 1 mm) are utilized. On the other hand, the volume fractions of resin and fiber in the conductive composite must be considerably lower to accommodate the conductive powder component. See column 4, line 61 to column 5, line 13 (emphasis added).**

Table I of Wilson lists several composites that contain both graphite powder and fiber reinforcement. The length of the fiber reinforcement ranges from 200 to 800µm (i.e., 0.2 to 0.8 mm), and qualifies as “microfiber” as therein described (i.e., fiber that is less than 1mm in length). Thus, in Wilson, the addition of short fiber less than 1 mm in length, preferably a graphite or cotton microfiber, is disclosed as a means of improving the mechanical properties of the composite. Although Wilson mentions long glass fiber, it is in the context of teaching away from the use of such materials.

As illustrated by the data provided in the subject application, samples molded from a pultruded polyphenylene sulfide composite that contained 40 weight percent of long glass fiber 11mm in length (Samples 1 and 2) were shown to have significantly higher flexural creep resistance than a sample molded from a PPS composite that contained 40 weight percent of glass fiber of “conventional short glass fiber” 1mm in length (Sample 3). At page 9, lines 15 to 17 the instant application notes:

Endplates fabricated from Samples 1 or 2 are expected to have greater dimensional stability and resistance to warpage under load than endplates fabricated from Sample 3.

While the long glass fiber-containing composites of Samples 1 and 2 are among the composites described by claims 1, 14 and 20, the short glass-containing composite of

Sample 3 (a material having significantly lower flexural creep resistance than the long fiber reinforced composites of Samples 1 and 2) is not.

Plastics generally fall into one of two main classes of materials: thermosets and thermoplastics. An overview of plastics, including a brief description of thermosets and thermoplastics is provided in "A Plastics Primer", by Dr. James F. Carley (copy attached), appearing at pages 4 to 8 of the 1988 edition of Modern Plastics Encyclopedia, published by McGraw Hill (copy attached). Thermoplastics exist as fluids at temperatures above their melting point, solidify upon cooling and, return to a fluid state when remelted. In contrast, thermosets are typically chemically reactive in their fluid condition, harden by further chemical reaction (termed "cross-linking" or "curing") and, once cured, cannot be restored to the same state of fluidity that existed prior to curing. Thus, thermosets and thermoplastics are very different types of materials. The composite of Wilson is a thermoset as opposed to a thermoplastic material. See column 3, line 52, to column 4, line 22, for a description of the curing of the vinyl ester resins of Wilson. In contrast, the composites used in the practice of the subject invention are thermoplastic materials.

It is respectfully submitted that the long-fiber reinforced thermoplastic resin composites from which the subject endplates are formed are recognized in the resin art as being different from the "microfiber"-containing thermoset composites disclosed by Wilson. It is further submitted that the "consists essentially of" language of new claim 19 and the "consisting essentially of" of new claim 20 further distinguishes these claims from Wilson, wherein the composite from which the disclosed polar plates are formed is required to contain a significant amount of a conductive powder filler so as to form a connected) network of conductive particles to impart the desired electrically conductivity.

Regarding the Guthrie and Carlstrom patents, Applicants refer to and incorporate the arguments set forth in their prior amendment. The Office Action of May 29, 3003

attempts to equate the bipolar plates disclosed by Wilson with the endplates that are used to compress a stack of membrane electrode assemblies, noting that "the endplate is simply a single-ended biplate and hence, both fuel cell components (the biplate and endplate, are electrically conductive elements. Therefore both components can be interchangeably used within a fuel cell structure. Thus, the characteristics and properties of Wilson et al's bipolar plate also apply to the end plate". In actuality, in Wilson's figure of a fuel cell stack (Fig. 2) the end plates 34 and 36 are clearly shown as being different parts than the stack of bipolar plates 10. While the patent does include "cooling plates" under the term "bipolar plate", it does not disclose or suggest that the parts shown as endplates are to be considered to be bipolar plates.²

Given the structural differences between the endplate assemblies disclosed by Guthrie and Carlstrom and the bipolar plates disclosed by Wilson, it is respectfully submitted that the combination of such references is mere hindsight. Moreover, even if combined, the combination fails to disclose the subject invention. As noted in the Applicants' Amendment of May 9, 2003, neither Guthrie nor Carlstrom disclose the criticality of using composites comprising a significant amount of long strand glass fibers at least 5 mm in length in fabricating fuel cell endplates, in fact, Guthrie is silent on the length of the fiber component of its polymeric material, and Carlstrom merely discloses forming its housing 52 from "a plastic material such as RYTON polyphenylene sulfide"

²The full description of Figure 2 appears at column 3 of the patent:

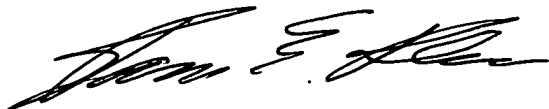
In FIG. 2, a plurality of membrane electrode assemblies 12 are placed alternately in series with bipolar plate 10, which serve to electrically connect in series anodes 16 and cathodes 18 (see Fig. 1 for fuel cell assembly references). End plates 34, 36 contact end ones of bipolar plates 10, and tie rods 38 are tightened to compress the stack of bipolar plates 10 and membrane electrode assemblies 12 between end plates 34, 36. In many stack designs, cooling plates are periodically interspersed between the fuel cell assemblies. Instead of a reactant, coolant is distributed in some manner across the plate. Since the cooling plates basically need to satisfy the same requirements as the bipolar plates (e.g., conductivity, strength, flow distribution, etc.) and may be configured such that one side distributes coolant and the other side reactant, etc., such components will also be considered under the general term "bipolar plate". One figure of merit for fuel cell stack assemblies 30 is the power density, i.e., the amount of power produced per unit volume. Thus, providing thinner bipolar plates with molded fluid passages would act to increase the power density and decrease the cost per unit power output.

without mentioning the use of glass fiber. Neither of these citations remedy Wilson's failure to disclose a long fiber composite as described by the subject claims.

To summarize, fuel cell endplates fabricated from long fiber reinforced thermoplastic composites that contain a significant amount of long glass fiber at least 5 mm in length are not disclosed or rendered obvious by Wilson (which teaches bipolar plates made from a thermoset resin containing conductive powder or a combination of conductive powder and microfiber less than 1 mm in length) alone or in combination with Guthrie and/or Carlstrom.

In view of the foregoing, reconsideration and allowance of the subject claims is respectfully requested. A petition for an extension of time (two months) accompanies this response.

Respectfully submitted:



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